S.No. : 01 GH_ME_EGH_240919

Fluid Mechanics

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CLASS TEST 2019-2020

MECHANICAL ENGINEERING

Date of Test : 24/09/2019

ANSWER KEY ➤ Fluid Mechanics

1. (d)	7. (c)	13. (c)	19. (d)	25. (b)
2. (b)	8. (b)	14. (c)	20. (a)	26. (b)
3. (a)	9. (c)	15. (b)	21. (d)	27. (c)
4. (d)	10. (d)	16. (d)	22. (b)	28. (b)
5. (d)	11. (c)	17. (c)	23. (a)	29. (d)
6. (c)	12. (b)	18. (a)	24. (d)	30. (a)

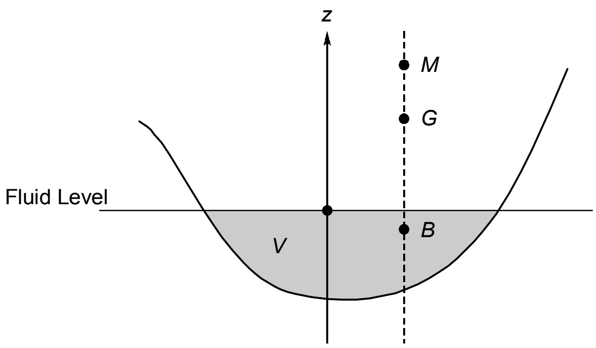
DETAILED EXPLANATIONS

4. (d)

$$\text{Specific weight of water} = 9810 \text{ N/m}^3$$
$$\text{Buoyant force} = \text{weight of water displaced}$$
$$10000 - 8500 = 9810 \times \text{volume} (V)$$
$$V = \frac{15000}{9810} = 0.153 \text{ m}^3$$
$$\text{Specific weight of metal} = \frac{10000}{0.153} = 65359.477 \text{ N/m}^3$$
$$\text{Specific gravity} = \frac{65359.477}{9810} = 6.66$$

5. (d)

Stable equilibrium condition



8. (b)

A mesh or network of stream lines and equipotential lines is called a flownet. The two sets of curves form a pattern of square.

9. (c)

Bernoulli's equation is applicable for an ideal and incompressible fluid when the flow is steady and continuous. In this, sum of the pressure head, velocity head and elevation head (or the sum of the flow, kinetic and potential energies per unit weight) of fluid is constant at all points in the flow system. Hence, correct option is (c).

10. (d)

Laminar friction factor, $$f = \frac{64}{\text{Re}}$$

where, Reynolds number, $$\text{Re} = \frac{\rho V D}{\mu}$$

$$f = \frac{64\mu}{\rho V D}$$

As water is flowing through both the tubes,

$$\rho, \mu = \text{constant}$$

Also, $$V = \text{constant} \qquad \text{(given)}$$

$$f \propto \frac{1}{D}$$

$$\frac{f_2}{f_1} = \frac{D_1}{D_2} = \frac{D}{2D} = 0.5$$

11. (c)

Navier-strokes equations are formulated by considering normal stresses. So, statement Q is not correct.

12. (b)

Momentum thickness, $$\theta = \int_0^\delta \frac{u}{U}\left(1-\frac{u}{U}\right)dy$$

Let, $$z = \frac{y}{\delta} \qquad (\text{For } y \to 0,\ z \to 0 \text{ and } y \to \delta,\ z \to 1)$$

$$\frac{u}{U} = 2z - z^2$$

$$= \int_0^1 (2z - z^2)(1 - 2z + z^2)\delta dz$$

$$= \delta\int_0^1 \left[(2z - z^2) - 2z(2z - z^2) + z^2(2z - z^2)\right]dz$$

$$= \delta\int_0^1 (2z - z^2 - 4z^2 + 2z^3 + 2z^3 - z^4)dz$$

$$= \delta\int_0^1 (2z - 5z^2 + 4z^3 - z^4)dz$$

$$\theta = \delta\left[z^2 - \frac{5z^3}{3} + z^4 - \frac{z^5}{5}\right]_0^1$$

$$= \delta\left(1 - \frac{5}{3} + 1 - \frac{1}{5}\right) = \delta\left(2 - \left(\frac{5}{3} + \frac{1}{5}\right)\right)$$

$$= \delta\left(2 - \frac{28}{15}\right) = \frac{2\delta}{15}$$

15. (b)

$$P_A + \sigma_{water}\, g(30 - 20) \times 10^{-2} = P_{atm} + \rho_{Hg}\, g(30 \times 10^{-2})$$

$$P_A + 9810 \times 10 \times 10^{-2} = P_{atm} + 13600 \times 9.81 \times 30 \times 10^{-2}$$

$$P_A + 981 = P_{atm} + 40024.8$$

$$P_A = P_{atm} + 39043.8$$

$$P_A = 1 + 0.39 = 1.39 \approx 1.4 \text{ bar}$$

16. (d)

$$V = \sqrt{2gh} = \sqrt{2g\left(\frac{\Delta P}{\rho g}\right)} = \sqrt{\frac{2\Delta P}{\rho}} = \sqrt{\frac{2\times 1\times 10^3}{1.2}} = 40.82 \text{ m/s}$$

17. (c)

In a flow field, vorticity is related to fluid particle velocity which is defined as twice of rotation vector i.e.

$$\zeta = 2\vec{\omega} = \nabla\times\vec{V} = \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)\vec{k}$$

$u = xy^2$, $v = 4xy$

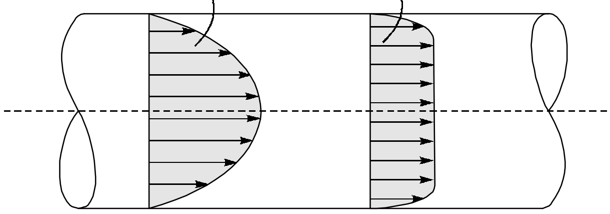
$$\frac{\partial v}{\partial x} = 4y$$

$$\frac{\partial u}{\partial y} = 2xy$$

$$\zeta = (4y - 2xy)\vec{k}$$

$$\zeta|_{(1,2)} = (4\times 2 - 2\times 1\times 2)\vec{k} = 4\vec{k}$$

20. (a)



Shear stress variation, $\tau = \frac{r}{2}\left(-\frac{dP}{dx}\right)$

21. (d)

$$\frac{L_e}{D} = 0.05\,\text{Re} \qquad (L_e \rightarrow \text{entry length})$$

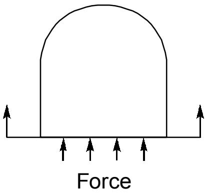
$$L_e \propto D\times \text{Re}$$

23. (a)

Terminal velocity, $U_t = \sqrt{\frac{4}{3}\left(\frac{\rho_P - \rho_f}{\rho_f}\right)\frac{gD_P}{C_D}}$ (for spherical particle)

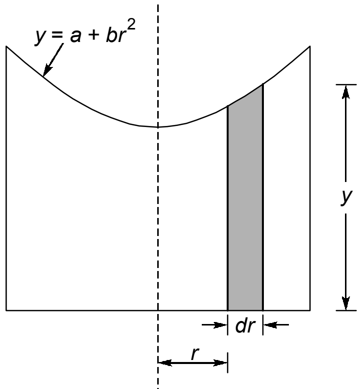
$$\frac{U_A}{U_B} = \sqrt{\frac{(\rho_A - \rho)}{(\rho_B - \rho)}} \qquad (D_P, C_P, \rho_f \text{ are constant})$$

24. (d)



$$P_{abs} = \text{gauge pressure} + \rho gh + \text{atmospheric pressure}$$
$$= 40 + 9.8 \times 2.5 + 101.325$$
$$= 141.325 + 24.5 = 165.8 \text{ kN/m}^2$$
$$\text{Force} = \text{Pressure} \times \text{area}$$
$$= 40 \times \pi(1)^2 = 125.66 \text{ kN}$$

25. (b)



Elemental mass, $$dm = (2\pi r)\, y\,(dr)\rho$$

total mass, $$m = \int dm = \rho\int_0^R (2\pi r)\, dr.y$$

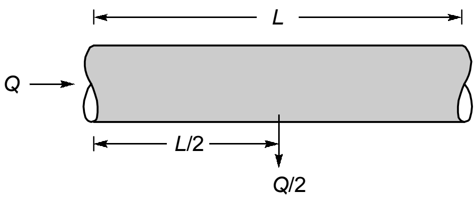
$$= \rho\int_0^R (2\pi r)\left(a + br^2\right) dr$$

$$= 2\pi\rho\left[\frac{ar^2}{2} + \frac{br^4}{4}\right]_0^R$$

$$m = 2\pi\rho\left[\frac{aR^2}{2} + \frac{bR^4}{4}\right]$$

$$m = \rho\pi R^2\left[a + \frac{bR^2}{2}\right]$$

26. (b)



Pressure drop, $$\frac{\Delta P}{\rho g} = hf = \frac{fLV^2}{2gD}$$

$$\frac{\Delta P}{\rho g} = \frac{fLQ^2}{2gDA^2}$$

$$\Delta P \propto LQ^2$$ [keeping other parameters constant]

$$\Delta P = KLQ^2$$ [where K is proportionality constant]

Discharge Q will be for half the pipe length and $\left(Q - \frac{Q}{2}\right)$ will be for remaining half.

$$\Delta P_1 = K\frac{L}{2}Q^2$$

$$\Delta P_2 = K\frac{L}{2}\left(\frac{Q}{2}\right)^2$$ [remaining discharge due to leakage$=\frac{Q}{2}$]

$$= \frac{KLQ^2}{8}$$

$$\text{New pressure drop} = \Delta P_1 + \Delta P_2$$

$$= KLQ^2\left[\frac{1}{2}+\frac{1}{8}\right] = \frac{5}{8}(\Delta P)$$

27. (c)

$$\text{Stress applied at top plate} = 3\tau_0$$

$$3\tau_0 = \tau_0 + K\left(\frac{du}{dy}\right)^{1/2}$$

$$\frac{2\tau_0}{K} = \left(\frac{du}{dy}\right)^{1/2}$$

$$\frac{du}{dy} = \frac{4\tau_0{}^2}{K^2}$$

$$\int_0^u du = 4\left(\frac{\tau_0}{K}\right)^2 \int_0^d dy$$

$$u = 4\left(\frac{\tau_0}{K}\right)^2 d$$

28. (b)

For incompressible fluid, $\nabla . V = 0$

$$\frac{\partial}{\partial x}\left[10\left(y^3 - x^2y\right)\right] + \frac{\partial}{\partial y}\left[2Cxy^2\right] = 0$$

$$10x(-2xy) + 4Cxy = 0$$

$$4C = 20$$

$$C = 5$$

29. (d)

$$a_x = \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = 0 + \left(\frac{V_0}{L}x\right)\left(\frac{V_0}{L}\right) + 0$$

$$a_x = \left(\frac{V_0}{L}\right)^2 x$$

$$a_y = \frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}$$

$$= 0 + \left(\frac{V_0}{L}x\right)\times 0 + \left(-\frac{V_0}{L}y\right)\times -\frac{V_0}{L} = \left(\frac{V_0}{L}\right)^2 y$$

$$\vec{a} = a_x\vec{i} + a_y\vec{i} = \left(\frac{V_0^2}{L^2}\right)\left(x\vec{i} + y\vec{j}\right)$$

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